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A Survey of Cone Beam Computed Tomography Use for Endodontic Treatment Among General Dentists in the American Dental Association

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Abstract

Introduction: The use of cone beam computed tomography (CBCT) has gained popularity and become more accessible to general dentists in clinical practice. The purpose of this study was to investigate the availability and integration of CBCT imaging for endodontic treatment among general dentists who are members of the American Dental Association (ADA). **Methods**: An invitation to participate in a web-based survey was sent to 81,091 members of the ADA. The survey consisted of fifteen questions on CBCT access, type and amount of CBCT training, fields of view (FOV), reasons for use, CBCT reports, and demographics. **Results:** Of the total number of 1,435 survey responses received, only the 1,366 from general dentists were included in the results. The percentage of general dentists that complete endodontic procedures was 81.0% with 38.2% of those having access to an on-site CBCT unit. Oral surgery offices and endodontic specialty offices provide access to a CBCT machine for another 29.0%. General dentists that have no access to CBCT in their area totaled 27.0%. Types of CBCT training varied widely with 64.0% of dentists having 8 hours or less of training. CBCT was used most often for identification of resorption and missed or calcified canals. When a general dentist considers referral, 60.0% are more likely to refer to an endodontist who regularly uses CBCT imaging. **Conclusion:** The results of our study show that almost half of the general dentist in the ADA who complete endodontic procedures have access to CBCT. The use the scans are used most often to identify resorption and missed canals.

The use of cone-beam computer tomography (CBCT) has gained popularity over the past 10-15 years as it has become more accessible to dentists at the individual practice level. In endodontic treatment, it can be viewed as an essential tool. CBCT imaging has the benefit of greatly reducing the radiation dose to patients compared to standard computed tomographic (CT) imaging, while a limited field of view (FOV) scan provides a high resolution image with little distortion (1–3). Periapical x-ray imaging has been the standard imaging modality for endodontic treatment, but it is not without its challenges. Periapical images are 2-dimensional with overlapping of any complex anatomy between the x-ray source and the image receptor (4). Depending on the angle of the x-ray source and the sensor, there can be significant dimensional distortion (4). The noise and dimensional distortion can leave us with difficulty determining diagnosis of the periapical region and assessing root and canal morphology. With the advent of CBCT, endodontists have found the technology useful for all stages of treatment to include diagnosis, initial treatment, nonsurgical and surgical retreatment, and outcome assessment (5). More specifically, CBCT is used in identifying complex root canal morphology and surrounding anatomy in 3D, external and internal resorption, vertical root fractures, localization of missed canals, and assessment of dental trauma (5,6).

The importance of CBCT in modern day endodontics and its use by specialists is greatly increasing. In a 2017 study by Setzer et al., approximately 80% of endodontists surveyed had access to CBCT with just over 50% having a machine in their dental practice (5). Endodontists

used CBCT most often for visualizing internal or external resorption, cases of missed canals and preoperatively for nonsurgical retreatment (5). With the availability of CBCT becoming widespread in procedures outside of endodontics, such as implant planning, pathology diagnosis, and surgical planning, the general dentist may have more opportunity to integrate the imaging modality into daily treatment (5,7). The purpose of this study was to investigate the availability and integration of CBCT imaging for endodontic treatment among general dentists who are members of the ADA.

Materials and Methods

A 15 question survey was e-mailed using the Uniformed Services University of Health Sciences Survey Monkey website to 81,091 members of the American Dental Association. A list of ADA member e-mail address was requested through the ADA for the purposes of educational research. The ADA member list was requested for general dentists only. The e-mail invitation from Survey Monkey served to introduce the survey as being part of a post-graduate endodontic research project and included the consent for participation in the study. All responses were collected anonymously. The initial survey was sent out followed by automated e-mail reminder 3 weeks later to those who had not completed the survey. Of the 15 questions that were included in the survey, 5 questions design to filter out participants who had already completed specialty training and to collect demographic information such as age, years since graduating dental school, and clinical practice setting. In addition to filtering those individuals who had previously completed specialty training, if the respondent answered 'no' to whether they perform endodontic procedures, they were excluded from participation.

For those respondents who had not completed specialty training and who perform endodontic therapy, a series of 10 questions were asked to assess what teeth providers complete endodontic therapy on, accessibility to a CBCT machine, and frequency of use and rationale. Additional questions to assess what barriers general dentists have to using CBCT, how many hours or training they have received, field of view routinely ordered, CBCT reporting, and influence of CBCT access on referral preference. If a participant did not use CBCT in their practice, they were asked what reason best describes why it was not used. Participants were required to choose at least one answer to every question. According to the response of the participant, it was possible for a question to be skipped, such as if a participant does not order CBCT scans then they were not required to answer questions about frequency of use and rationale.

Results

There were 81,091 emails were sent out through the Survey Monkey platform. 17,852 emails were received and opened by the recipient. Of the e-mails that were opened, 1463 clicked to begin the survey and 1366 completed it to its entirety. The response rate for the survey was 7.65%. A significant majority of participants graduated from dental school over 20 years ago (n = 963, 70.5%). There was a fairly equal distribution of other participants with 137 (10%) graduating 16-20 years ago, 97 (7.1%) graduating 11-15 years ago, 68 (5%) graduating 6-10 years ago, and 101 (7.4%) graduating within the past 5 years.

Solo providers in private practice were the predominate clinical setting of participants (n = 771, 56.4%) followed by providers in a group practice (n = 494, 36.2%). Under 2% of participants practice in a multispecialty office, hospital setting, education, or military clinic (n = 26, 20, 25, 25 respectively). There were 58 participants (4.25%) that answered 'other' with some being retired, working in non-profits, and others working public health. The primary method of reimbursement was private insurance for 435 participants (31.8%), equal amount of fee for service and private insurance for 409 participants (30%), and 391 participants (28.6%) providing fee for service. Other participants accepted mostly state or federal reimbursement (n = 65,

4.8%) or do not directly get reimbursed for procedures performed such as in the military or Indian health system (*n* = 47, 3.4%). Only 19 participants (1.4%) specified 'other' with most being either retired or in academics.

Out of the responses received, 69 (4.72%) respondents were excluded for having attended specialty training as the purpose of the study is to focus on CBCT use by general dentists. Another 261 (18.76%) respondents were excluded for not completing endodontic procedures. Maxillary anterior teeth were treated by 98.66% (*n* = 1105) of the providers. Maxillary premolars were treated by 95.18% (*n* = 1066) of participants and mandibular premolars were treated by 94.91% (*n* = 1063). Mandibular anterior teeth were treated by 92.05% (*n* = 1031) of the participants. Molars were the least common teeth to be treated by general dentists. Only 65.71% (*n* = 736) treated mandibular molars and just 59.73% (*n* = 669) treated maxillary molars.

Of the total of 1120 participants who are general dentists and perform endodontic procedures, 528 (47.14%) have a CBCT unit on-site. An endodontic office provides access to CBCT units for 173 (15.45%) providers and an oral surgery office provides access to 150 (13.39%) providers. Neighboring orthodontists, periodontists, and dental imaging centers provide access for another 140 (12.5%) of the participants. There were an additional 28 (2.5%) 'Other' responses with locations such as a neighboring general dentist office (*n* = 10) and mobile CBCT units (*n* = 6) being the most common response (Fig. 1). When comparing the time since graduation from dental school to access to CBCT, 54.43% (*n* = 43/89) of those graduating less than 5 years ago had on site access to CBCT. For those who graduated more than 20 years ago, access to onsite CBCT was 45.10% (*n* = 322/890), a statistically significant difference compared to those gratuating less than 5 years ago.

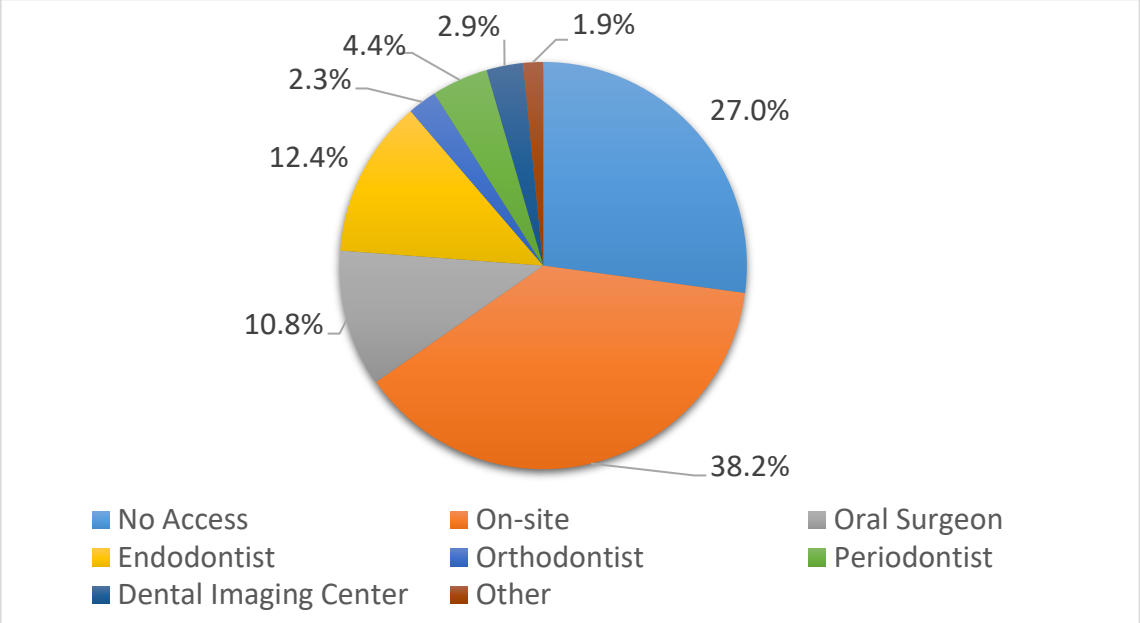

Figure 1. CBCT access by location of general dentists in the American Dental Association.

Figure 2 shows the use of CBCT by providers varies based on procedure. For nonsurgical root canal therapy, 39.14% (*n* = 200) either never or rarely order a CBCT scan, 26.81% (*n* = 137) sometimes order a scan, and 33.42% (*n* = 271) responded that they order a scan often or always. There was 48.73% (*n* = 249) of participants who responded that CBCT is not applicable to surgical root canal therapy, likely a result of general dentists not performing surgical root canal retreatments. CBCT was most commonly used by the general dentist for implant planning, with 78.28% (*n* = 400) responding that they use it often or always. Prosthodontic and restorative procedures also saw more infrequent use with 53.23% (*n* = 272) using it never or rarely, 26.81% (*n* = 137) use it occasionally, and 14.68% (*n* = 75) use it frequently or always.

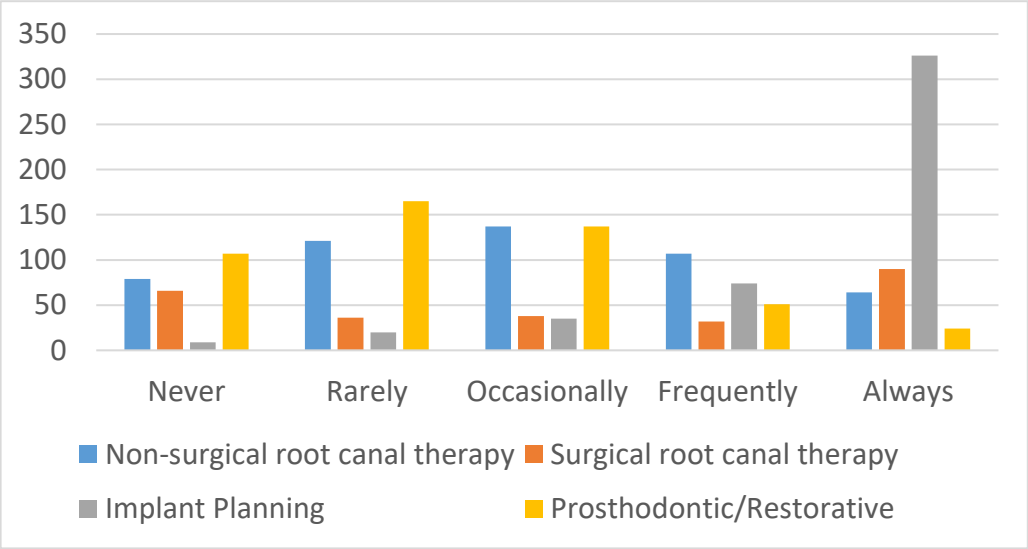

Figure 2. CBCT frequency of use by procedure.

For endodontic specific indications a significant number of participants used CBCT most often for identification of missed canals (61.62%, *n* = 215) and for identification of resorption (60.30%, *n* = 308) (Fig. 3). CBCT to identify morphology is used less often with only 44.62% (*n* = 228) ordering a scan often or always. Identification of calcified canals were likely to have a CBCT scan never or rarely taken by 30.33% (*n* = 155) respondents with 45.98% (*n* = 235) using it often or always. Lastly, identification of a PARL with CBCT was never or rarely used by 18.20%% (*n* = 93), 32.09% (*n* = 164) used it frequently, and 49.71% (*n* = 254) used it frequently or always.

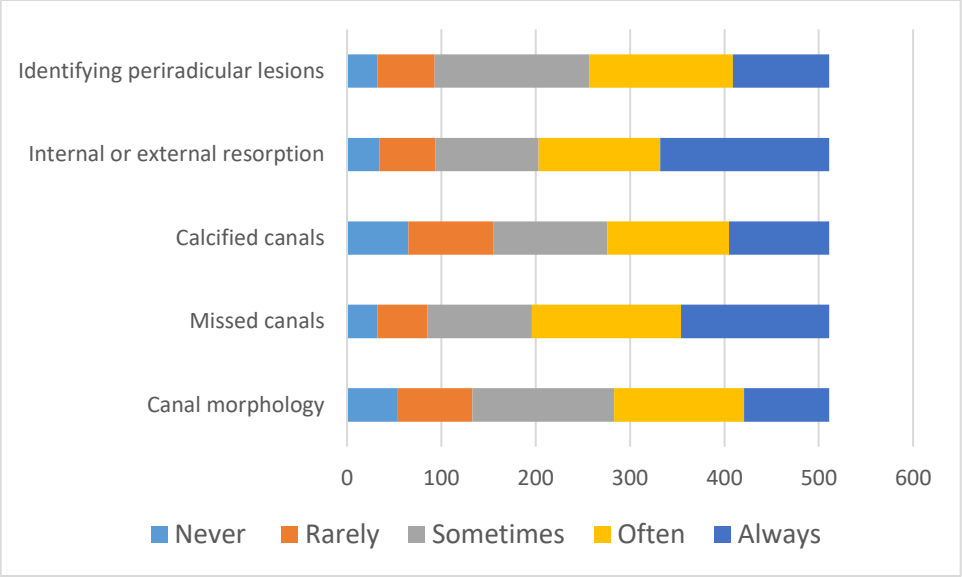

Figure 3: CBCT frequency of use by procedure.

A total of 350 (31.53%) of the 1110 responses have not had any of the listed CBCT training options. Manufacture training was the most common with 38.65% (*n* = 429) followed by 29.64% (*n* = 329) attending free continuing education (CE), 27.93% (*n* = 310) attending paid CE, and 27.66% (*n* = 307) attended dental conference presentations. When it comes to the total number of hours of training received, 36.4% (*n* = 277) had received only 1-4 hours, 28.38% (*n* = 216) had received 5-8 hours, 15.64% (*n* = 119) had 9-16 hours, and 19.58% (*n* = 149) had received more than 16 hours.

Field of view, an important aspect of CBCT scans, was unknown by 483 (45.14%) participants. Small/Limited field of view (FOV), ≤5 cm, was ordered by 214 (20%), medium FOV (6-10 cm) by 235 (21.96%), and large FOV (>10cm) by was ordered by 138 (12.9%) of dentists. For completion of the CBCT report, of the responses received, 51% (*n* = 1070) don't order CBCT imaging. There were 162 general dentists who write their own report was (15.14%). Another 180 (17.82%) dentists typically write their own report and occasionally refer to an oral and maxillofacial radiologist (OMFR) (12.62%, *n* = 135) or medical radiologist (4.21%, *n* = 45). General dentist who always send the scan to an OMFR totaled 95 (8.88%) or medical radiologist 2.34% (*n* = 25). The final report is completed by someone other than an oral and maxillofacial radiologist or medical radiologist at the clinic where the respondent refers patients totaled 62 (5.79%).

For the participants who don't use CBCT for endodontic treatment, the most common reason for not using it was because the provider refers the case out to a specialist if a 3-dimensional scan is needed (*n* = 293, 28%). Cost was the next largest factor for 188 respondents (18%). There was 140 participants (13.4%) who responded that intraoral periapical imaging is sufficient for their practice. In the 'other' response (*n* = 46, 4.4%), there were a variety of response such as "lack of space", "no room", "lack of training", "worry of unwanted radiation", and "patients can't afford it". Participants responded that an endodontist's access to CBCT is more likely to be considered when referring (*n* = 639, 21.1%), less likely to be considered for only 11 participants (1%), and 394 (37.7%) responded that CBCT does not influence their referral.

Discussion

The purpose of this study was to investigate the availability and integration of CBCT imaging for endodontic treatment among general dentists. In general, CBCT 3-dimension technology

has many advantages over standard 2-dimensional periapical imaging. With the increased availability of machines on the market and the decreasing cost, it has opened up the availability of the technology to an increasing number of dentists. Recent publications on this topic have focused on the integration of CBCT technology by endodontists in the United States and other studies were published to investigate the use by dentists in the United Kingdom, Turkey, Sweden, and Norway (5,8–10). Participation rates in these ranged from 35.2% in survey by Setzer et al. of endodontists in the United States (5) to 71% in the Strindberg et al. study of Swedish and Norwegian dentists (9) which is significantly higher than the 7.65% in our study.

Our study found that 72% of participants have access to a CBCT unit in their area with 38.2% having a unit physically at their office. This is less than the results of the survey by Setzer et al who found 50.69% of endodontic practitioners have access to an in office unit (5). A later study by Alzamzami et al. found 86% of AAE member dentists surveyed had in-office access to CBCT (11). These results demonstrate that general dentists are integrating the technology into their practice, though not to the extend as specialists.

The general dentist is typically the first line provider and first to provide diagnosis and recommendation for treatment. The ability of a general dentist to take a 3-dimensional scan and accurately diagnose or visualize canal morphology will help determine treatment. In a study by Aminoshariae et al, it was found that CBCT imaging has twice the odds of identifying apical lesions than conventional periapical imaging (12). This is supported in the earlier study by Abella et al, who found CBCT to be beneficial in identifying lesions in teeth with symptomatic apical periodontitis (SAP) (13). Lesions in teeth with SAP can be more difficult to identify as they are smaller and harder to visualize through the cortical bone on a 2-dimensional periapical image. This can result in more proper case selection and may lead to a higher level of endodontic care provided at the general dentist level.

According to the American Association of Endodontists (AAE) and American Academy of Oral and Maxillofacial Radiology (AAOMR) position statement, CBCT use is recommended in many aspects of endodontic treatment to include diagnosis, initial treatment, nonsurgical treatment, surgical treatment, special conditions such as trauma, implants, or resorption, and outcome assessment (14). Our study indicates that the general dentists have access to the technology, but according to the indications for use, the general dentist does not use the 3-dimensional scans as often as justified. Responses to our survey indicate that CBCT use by general dentists is used ‘often’ or ‘always’ by 61.6% of participants for identification of missed canals and 60.2% of general dentists used CBCT ‘often’ or ‘always’ for identification of internal or external resorption. In these cases of missed canals or resorption, treatment decisions are directly affected and the CBCT put this ability directly into the hands of a general dentist without having to refer to a specialist. According to results of our survey, general dentists appreciate the importance of CBCT in certain cases and 61% of participants agree that they are more likely to refer to an endodontist who uses CBCT regularly.

One of the concerns with using CBCT is the increased radiation dose a patient receives when a scan is captured (14). It is recommended by the AAE and AAOMR position statement that intraoral periapical imaging should be the modality of choice in the endodontic evaluation (14). In cases where additional information is needed and a CBCT is justified, providers should use the smallest field of view possible to avoid unnecessary radiation exposure. In our study, we found 20% of participants stated they use a small/limited FOV (≤5cm) and an additional 21.96% use a medium FOV (6-10cm). There were 45.1% of the participants that were unsure of what size scan they were exposing patients to. The first step in ensuring you are using the ALARA principle is to know what FOV is required to scan only what is needed. In general, a single tooth in question and lesion can be scanned in a small/limited FOV (≤5cm). This FOV can be increased in situations where more than one tooth requires imaging or if taking two scans of teeth in close proximity could be imaged in one slightly larger FOV.

Another important aspect of FOV ties into the writing of the scan report. When a CBCT image is obtained from a patient, there is a chance that of incidental findings that should be included in the report. A provider is liable for the information obtained in the imaging and should report what is visualized. In a study by Johnson et al., it was found that in 474 radiology reports on CBCT scans, incidental findings were found in 51.5% of the scans (15). Of the incidental findings more than half were endodontic or sinus related and 70.5% were of the findings were sent for referral or additional treatment (15). In our study, 30.9% of general dentists always write the report themselves and another 34.3% write the report most of the time and occasionally refer to an oral and maxillofacial radiologist (OMR) or medical radiologist. We know according to a study by Oser et al., that a radiologist is more likely to identify incidental findings (16). CBCT imaging can provide a wealth of information about a case, but care should be taken to ensure proper reporting of the report, to include reporting by an OMR or medical radiologist when needed.

Training in the use of CBCT in our study showed a majority of respondents (64.8%) having received less than a full day of training and only 12.7% of participants received training in their dental school curriculum. Considering the demographics of the participants in this study, it seems reasonable that such a small percentage have received CBCT education in school. The technology is just now becoming more mainstream and integrated into dental education and this correlates to the more experience general dentists never receiving training in school.

Cost remains to be a considerable factor in CBCT use among dentists. This is consistent with previous surveys of endodontists (5,11). As the cost of entry level CBCT machines continues to decrease, the integration of CBCT will increase as well. One of the main considerations for offsetting the cost of the scans is determining who pays for the scan. Some endodontists include the fee in their treatment fees and others charge patients an additional fee in addition to the procedure fee (11). Reimbursement will remain contentious until insurance reimbursement begins for the procedure.

Limitations of the Study

The survey for this study was e-mailed out using the Survey Monkey platform through a Uniformed Services University of Health Sciences e-mail address. This platform allowed us to target a very large number of members of the ADA. Our response rate was, however, very low compared to similar studies. One of the primary issues with using the Survey Monkey platform was a large number of survey e-mails were never delivered to the desired recipients. Modern spam filtering prevented the delivery of many emails to a recipients' inbox and were instead diverted filtered as spam and routed to the recipients' junk folder. This resulted in only 22% of the survey emails being received and opened by the recipient. Out of the emails that were received by the recipients, only 7.65% responded. Although the email list provided by the ADA was only supposed to contain general dentists, there was no guarantee that all of the members are practicing dentists. Demographic information of the respondents shows 80.5% of those who responded graduated from dental school over 16 years ago. This is significant when the availability of CBCT has increased recently and the training would be incorporated more often in dental school training of recent graduates. It can only be assumed as to why there was such a low participation in the survey. Possible reasons for the response rate include: the list of email address provided to us by the ADA could have favored the older population or the older graduate population is more likely to complete an online survey for research purposes. The low response rate is a concern as it can lead to a non-response error where many general dentists not using CBCT technology did not want to participate in a survey regarding its integration since they do not use it. This non-response bias would lead to an apparent higher number of general dentists having access to the technology than those that actually do.

Conclusions

This survey shows there is use of CBCT use among general dentist who are members of the American Dental Association for endodontic procedures. There were 38.2% of general dentists with on-site access and 73.0% have access to CBCT in their immediate area. The use of the technology is something that is beneficial not only to specialty providers, but to the general dentist as well. Integration of CBCT with limited FOV scan, can provide essential imaging for the general practice which will allow for better case management and treatment planning, while minimizing radiation exposure for patients. Cost and space are major limiting factors faced by general dentists.

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